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Tier 2 Study White Paper

U.S. Environmental Protection Agency
Office of Air and Radiation
Office of Mobile Sources
Vehicle Programs and Compliance Division

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1. Introduction

1.1 Overview of Clean Air Act Requirement

The Clean Air Act Amendments (CAAA) of 1990 added subsections 202(g) and 202(h) to the Clean Air Act which required Phase I (or Tier 1) emission standards for light-duty vehicles and light-duty trucks, effective with a phase-in starting in 1994. The Amendments also added subsection 202(i), which requires a Phase II Study (hereafter referred to as the Tier 2 Study) to consider, *"whether or not further reductions in emissions from light-duty vehicles and light-duty trucks should be required pursuant to this title."* The Tier 2 Study is to serve as the foundation for potential revisions to the Tier 1 emission standards, and Congress gave explicit instructions on where EPA should start:

> *"The study shall consider whether to establish with respect to model years commencing after January 1, 2003, the standards and useful life period for gasoline and diesel-fueled light-duty vehicles and light-duty trucks with a loaded vehicle weight (LVW) of 3,750 lbs. or less specified in the following table:*
>
> | | |
> |---|---|
> | *NMHC* | *0.125 g/mi* |
> | *NOx* | *0.2 g/mi* |
> | *CO* | *1.7 g/mi* |
>
> *For vehicles and engines subject to this subsection for purposes of section 202(d) and any reference thereto, the useful life of such vehicles and engines shall be a period of 10 years or 100,000 miles (or the equivalent), whichever first occurs.*
>
> *Such study shall also consider other standards and useful life periods which are more stringent or less stringent than those set forth in table 3 (but more stringent than those referred to in subsections (g) and (h)).*"
>
> (See table 1 for a comparison to existing standards.)

The CAAA also outlined the critical elements which EPA is to consider in the course of the study:

- Air quality need. EPA *" shall examine the need for further reductions in emissions in order to attain or maintain the national ambient air quality standards..."*

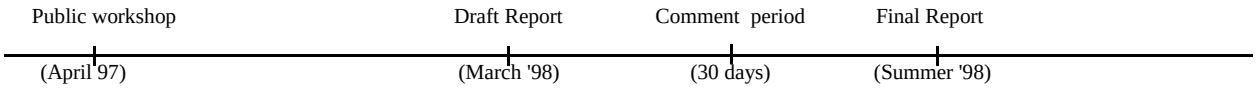
- Technology assessment. EPA is to examine *"the availability of technology (including the costs thereof), in the case of light-duty vehicles and light-duty trucks with a loaded vehicle weight (LVW) of 3,750 lbs. or less, for meeting more stringent emission standards than those provided in subsections (g) and (h) for model years commencing not earlier than after January 1, 2003, and not later than model year 2006, including the lead time and safety and energy impacts of meeting more stringent emission standards."*

• Cost effectiveness assessment. EPA is to examine *"the need for, and cost effectiveness of, obtaining further reductions in emissions from such light-duty vehicles and light-duty trucks, taking into consideration alternative means of attaining or maintaining the national primary ambient air quality standards pursuant to State implementation plans and other requirements of this Act, including their feasibility and cost effectiveness."*

1.2 Overview of Tier 2 Study

1.2.1 Tier 2 Study Framework

In fulfilling the Congressional Clean Air Act requirement, EPA intends to involve all interested parties early in the process to insure an informed and representative evaluation. To this end, EPA will hold a public workshop on April 23, 1997 to frame the issues and to solicit input. Building on information received at the workshop, EPA will conduct the Tier 2 Study with a target completion date of March 1998 for a draft report. EPA will take comments on the draft report and include a summary of the comments in a final report to Congress by early summer of 1998 (see time line below).



1.2.2 Tier 2 Study White Paper

The charge in 202(i) to determine if any additional regulation should be required can be addressed in a variety of ways. The purpose of this white paper is to present EPA's initial plan for defining the scope of the Tier 2 Study. It is important to note that EPA has not made any determination regarding elements in the Tier 2 Study, and EPA is particularly interested in receiving feedback from all parties as to the scope of the study. This document will serve as the basis for the public workshop, described above, presenting issues identified by EPA as having potential importance to the Tier 2 Study. EPA welcomes comment, in writing or at the workshop, on the specific issues raised in the white paper, as well as comments on additional issues not captured by this initial review.

After a background section to set the context for the Tier 2 Study, the paper is divided into three sections: air quality assessment, technology assessment, and cost-effectiveness assessment. Each section outlines EPA's proposed activities and a discussion of issues.

2. Background: Vehicle Emission Control Programs and Air Quality Developments Since the 1990 Clean Air Act Amendments

2.1 Vehicle Emission Control Programs

Chronologically, the Tier 2 Study is one of the last mobile source requirements in the 1990 Clean Air Act Amendments. During the six years since the CAAA's passage, EPA has implemented a number of new programs and there have been real improvements in urban air quality, as well as improvements in our understanding of the science of air pollution. All these factors impact the

scope and direction of the Tier 2 Study. This section briefly reviews key programs and developments: Tier 1 standards, Cold CO rulemaking, on-board diagnostics (OBD) requirements, Federal Test Procedure revisions, and the National Low Emission Vehicle program.

2.1.1 Tier 1 Standards

The exhaust emission standards and procedures that currently apply to new LDVs and LDTs, known as the Tier 1 standards, were promulgated by EPA on June 5, 1991 (56 FR 25724), as required by the 1990 CAAA. The Tier 1 program includes standards for non-methane hydrocarbon (NMHC), oxides of nitrogen (NOx), carbon monoxide (CO) and particulate matter (PM), all measured over the Federal Test Procedure (FTP) and applicable for the full statutory useful life of the vehicle. The phase-in of these standards began with the 1994 model year; as of the 1997 model year all light-duty vehicles and all categories of light-duty trucks must comply with the full set of Tier 1 standards.

2.1.2 Cold CO

In September of 1990, EPA published a Notice of Proposed Rulemaking proposing regulations requiring light-duty vehicles and light-duty trucks to meet cold temperature CO emission standards for their useful life. Two months later, the CAAA were passed and they included a requirement that EPA promulgate regulations controlling cold CO emissions. Like the revisions to the Clean Air Act exhaust emission standards, the Clean Air Act provided for the establishment of cold CO standards in two phases. The first phase, completed with an EPA final rule in July of 1992 (57 FR 31888), established emission standards for CO to be measured on the FTP at a temperature of 20°F. The phase-in of these standards commenced with the 1994 model year and became complete with the 1996 model year. The second phase of addressing cold CO emissions, as required by subsection 202(j)(2) of the CAA, is to consist of an EPA study addressing the need for and feasibility of additional CO reductions. EPA is currently conducting this study, which is required to be complete by June 1, 1997. In addition, the Clean Air Act includes a specific set of standards to be implemented starting in the 2002 model year if certain triggering nonattainment conditions exist as of June 1, 1997.

2.1.3 On-board Diagnostics (OBD)

As required by section 202(m) of the Clean Air Act, EPA promulgated regulations establishing requirements for on-board diagnostic systems on light-duty vehicles and light-duty trucks which began with the 1994 model year. The purpose of the OBD system is to assure proper emission control system operation for the vehicle's full useful life by monitoring emissions-related components and systems for deterioration and malfunction. The sensors and actuators, along with the diagnostic computer software in the on-board computer, make up what is called "the OBD system." An important aspect of OBD is its ability to notify the driver of a problem before the vehicle's emissions have increased significantly. If the vehicle is taken to a repair shop in a timely fashion, it can be properly repaired before any significant emissions increases occur. Such early detection also minimizes the likelihood of more costly repairs which may have been

incurred had the problem gone undetected. OBD systems will also provide automobile manufacturers with valuable feedback from their customers' vehicles which can be used to improve vehicle and emission control system designs.

2.1.4 Federal Test Procedure Revisions

The Federal Test Procedure (FTP), discussed above, is the vehicle test procedure that is used by EPA to determine the compliance of light-duty vehicles and light-duty trucks with the conventional or "on-cycle" Tier 1 exhaust emission standards. The FTP is used to test vehicle emissions performance on a "typical" driving schedule, using a dynamometer to simulate actual road conditions. As a result of the CAAA requirements, EPA promulgated changes to the Federal Test Procedure on October 22, 1996 (61 FR 54852) that revise the FTP to replicate actual driving patterns more accurately. In addition to requiring an equipment change to the existing FTP, the revisions added new "off-cycle" test sequences (the Supplemental Federal Test Procedure, or SFTP) and emission standards to control emissions under driving patterns not tested under the conventional FTP. These new standards and associated test procedures begin a phase-in with 40 percent of a manufacturer's fleet in the 2000 model year, 80 percent in 2001, and 100 percent in model year 2002. Low volume manufacturers and light-duty trucks over 6,000 GVWR (gross vehicle weight rating) have a two year delay in this phase-in schedule.

2.1.5 National Low Emission Vehicle (NLEV) Program

The proposed NLEV program is a unique voluntary program that will allow auto manufacturers the option of complying with tailpipe emission standards that are more stringent than the Tier 1 standards. In early 1994 the Ozone Transport Commission (OTC) recommended that EPA require all OTC states to adopt the more stringent California Low Emission Vehicle (CAL LEV) program. EPA approved this petition in December, 1994, finding that further emission reductions from motor vehicles are required to mitigate the effects of air pollution transport in the region and to bring ozone nonattainment areas in the region into attainment by the dates specified in the Clean Air Act. EPA also stated that a nationwide program was the best method for achieving the desired emission reductions, rather than a state-by-state adoption of the California LEV program limited to the Northeast states. Discussions between EPA, the OTC states, and the automobile manufacturers resulted in a draft Memorandum of Understanding that outlined such a nationwide program and formed the basis of a Notice of Proposed Rulemaking published on October 10, 1995, detailing the structure of the NLEV program (60 CFR 52734). In general, the NLEV standards and related requirements are patterned after California's more stringent tailpipe standards and fleet average NMOG standards, although they do not apply to light-duty trucks over 6,000 GVWR. The requirements would initially apply only to vehicles sold in the Northeast states, but would extend to the rest of the country (except California) in the 2001 model year. The NLEV program is dependent on the OTC states and auto manufacturers voluntarily committing to the program because EPA does not have the authority to require the OTC states to accept the NLEV program in place of the current regulatory requirements, and the Clean Air Act expressly forbids EPA from mandating standards more stringent than the Tier 1 levels before the 2004 model year.

2.2 Air Quality Developments

EPA tracks air quality in two different manners: air concentrations based on actual ambient measurements of pollutants at monitoring sites across the country (generally located in urban areas), and emissions based on estimates of the total tonnage of the pollutants released into the air annually. The most recent data summarized by the Agency show improvements in air quality for all principal pollutants over the last ten years, both in terms of measured concentrations and total emissions (National Air Quality and Emissions Trends Report, 1995, EPA Document 454/R-96-005, October 1996).

EPA is responsible for setting National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment and for ensuring that these standards are attained. The Clean Air Act established two types of NAAQS - primary and secondary. Primary standards are limits set to protect public health, while secondary standards are limits set to protect public welfare, including protection against damage to agricultural crops, visibility, and natural vegetation. EPA has set NAAQS for six principal pollutants: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO2), ozone (O3), particulate matter (PM), and sulfur dioxide (SO2).

On November 29, 1996, EPA proposed revisions to the primary and secondary NAAQS for ozone and particulate matter. The proposed revisions to the ozone NAAQS would replace the current 1-hour primary standard with a new 8-hour standard to protect against longer exposure periods that are of concern at ozone concentrations below the level of the current standard. The proposed revisions to the primary particulate standard would retain the current annual standard for PM-10 (particles 10 micrometers and smaller), but would add a new annual standard for PM-2.5 and a new 24-hour standard for PM-2.5. The EPA also proposed to revise the secondary standards for both ozone and PM by making the secondary standards equal to the proposed primary standards. The EPA also specifically sought comment on a number of other alternatives, and EPA will finalize the new standards by July 19, 1997.

3. Air Quality Assessment

3.1 Introduction

This first element of the study, the air quality assessment, examines the question of the need for further reduction in emissions from light-duty motor vehicles in order to attain or maintain the National Ambient Air Quality Standards (NAAQS).

Assessing air quality can be thought of as involving three steps:

1. For a specific point in time, determine the geographic areas which fail to meet the air quality standard (NAAQS).
2. For the nonattainment areas identified in step 1, establish the level of emission reductions needed to reduce ambient concentrations of the criteria pollutant to a level which would bring these areas into attainment of the NAAQS.
3. Completion of step 2 provides an emission reduction target for each area. National and area-specific emission inventory information on the sources of the ozone precursor emissions can then be used to establish source-specific emission reduction targets.

Each step of the above process has uncertainties, and significant resources are required to carry out the underlying emission inventory and air quality modeling. For ozone there is the added complexity that light-duty motor vehicle regulations control ozone precursor emissions and not ozone directly. OMS will seek to utilize existing air quality assessments in its Tier 2 Study. OMS will coordinate with the ongoing efforts of the Ozone Transport Assessment Group (OTAG) and the Subcommittee for Ozone, Particulate Matter and Regional Haze Implementation Programs established under the Federal Advisory Committee Act (FACA) . With regards to the CO assessment, the Tier 2 Study will coordinate with the ongoing work in support of the Cold CO Study.

3.2 Issues

This section frames the potential issues surrounding the key steps and assumptions involved in carrying out the air quality assessment. EPA welcomes comments on each of the issues discussed below, as well as any comments, general or specific, on air quality assessment.

Choice of Criteria Pollutants. The Act did not specify which of the NAAQS to consider; however, the suggested Tier 2 standards included in the Act indicate that OMS should look at the Ozone NAAQS (ozone precursor emissions, VOC and NOx) and the CO NAAQS (CO emissions). The NAAQS for particulate matter (PM) was not explicitly addressed in the 202(i) subsection requirement; however, recent evidence suggests that particulate matter is a serious health concern. It is EPA's intention to include PM in the air quality assessment.

Time Frame for Evaluating Air Quality Need. The support analyses for the proposed NAAQS revisions used 2007 as the year for evaluating air quality. The earliest possible implementation of more stringent Tier 2 standards is the 2004 model year, thus, a case can be made that it is more appropriate to assess air quality for the first year when new standards could be implemented. In either case, the full impact of the tighter tailpipe emission standards will not be realized for 12 to 15 years due to fleet turnover. Comments are solicited on the choice of the year for assessing air quality need.

CO Assessment. The recent improvement in air quality with respect to CO has been very encouraging. EPA seeks comments on any specific CO issues which should be considered as part of the study.

PM Assessment and Inventory Issues. Recent modeling suggests light-duty vehicles and light-duty trucks are not large contributors to the PM emission inventory. EPA seeks any data and information on particulate emissions from light-duty vehicles and light-duty trucks, both in terms of current and potential future impacts.

Secondary Particulate Formation. There is secondary formation of particulate in the atmosphere from SO2 and NOx emissions. Data and information are solicited on the relative importance of these secondary particulate emissions from light-duty vehicles and light-duty trucks. EPA also

requests information on how to estimate the level and health impacts of such secondary particulate formation.

4. Technology Assessment

4.1 Introduction

The technology assessment must consider the availability and cost of technology to achieve the emission reduction targets (if any) established in the air quality assessment. In assessing technology, both emission benefits and costs will be addressed.

4.2 Issues

This section frames the potential issues surrounding the key steps and assumptions involved in carrying out the technology assessment. EPA welcomes comments on each of the issues discussed below, as well as any general comments.

Baseline Assessments. NLEV (CA-LEV) stringency is the assumed starting point for the study, in large part because a number of vehicles meeting the CA-LEV emission levels have been certified for the 1997 model year and are available for assessment. NLEV is more stringent than the default Tier 2 standards from table 3 of subsection 202(i) for NMHC, but less stringent for NOx and CO (see Table 1). Comments on the appropriateness of using NLEV as the starting point for the study are solicited, as are data (including SFTP tests) on LEVs and ULEVs.

Relative Importance of HC versus NOx Control. Recent scientific evidence has made it clear that additional NOx and NMHC controls may be needed in many areas, especially areas where ozone concentrations continue to be high over a large region (as in the Southeast, Midwest and Northeast). The Ozone Transport Analysis Group (OTAG) was established by the States and EPA to make recommendations on the need for additional NOx and NMHC emissions controls to reduce interstate transport of ozone and ozone precursors. The OTAG air quality modeling work and recommendations, as well as the modeling efforts in support of the NAAQS revisions, will be closely followed and will be used to help establish the relative importance of additional NOx and NMHC control. Estimates of ozone benefits from reductions in both NMHC and NOx standards will be combined with estimates of the costs of reducing each pollutant to establish the relative level of NOx control desired in conjunction with NMHC control. Comments are solicited on the appropriateness of this approach to setting NOx and NMHC standards and establishing the relative importance of NOx versus NMHC control.

Costs and Emission Benefits of Emission Technology. As a starting point, the California LEV program will provide actual cost and emission benefit data for comparing LEV and Tier 1 technologies. This information will be valuable; however, as EPA considers the appropriate level of control for Tier 2, EPA will need to assess potential technologies (see Table 2) for achieving emission levels below the current Tier 1 standards. Data and information on the potential emission reductions and costs of these technologies are solicited, as are data on any other promising technologies.

Light Truck Standards. Neither the suggested Tier 2 standards in the CAAA or the NLEV program increase Tier 1 stringency for LDT categories 3 and 4 (Table 1 includes a description of LDT classes 1-4). Further, there is a substantial difference in the NLEV standards for LDT1s and LDT2s. Table 1 also lists the Tier 1 and CA-LEV standards for the various truck classes, as well as estimated 1996 sales. Emission standards for light trucks are a potential concern due to the continuing increase in the light truck share of the light-duty market. Figure 1 shows the car versus light truck historical market share. Light trucks have steadily increased their market share since 1982, with no signs of the increase leveling off. Should light trucks eventually reach 50% of the light duty market, as predicted by many market analysts, light trucks would account for about 53% of VMT (vehicle miles traveled) and 60-75% of light duty NOx emissions in 2010. The increasing dominance of light truck emissions in the future raises the issue of whether or not to reduce the difference in the stringency of the emission standards between passenger cars and the various LDT classes. The technology assessment conducted by EPA as part of the Tier 2 Study will include an analysis of the difference in engine size, vehicle weight, and load carrying capacities between the larger cars and the different light truck classes, plus an assessment of the potential impact of any differences on the appropriate emission standard level. EPA requests data and information addressing the feasible emission levels and associated costs for each truck class relative to car standards.

Harmonization with California Air Resources Board (CARB) and European Community. Both CARB and the European Community are considering the establishment of NOx standards considerably more stringent than NLEV NOx levels in the 2005-2010 time frame. Comments and data are solicited addressing the issue of whether there would be benefits in harmonizing Tier 2 emission stringency with CARB and/or the European Community.

Heavy-Duty Vehicles. Currently, EPA regulates trucks under 8,500 GVWR as light-duty trucks. Trucks above this weight are certified as heavy-duty vehicles and are subject to less stringent heavy-duty engine emission standards and different test procedures, such as certification testing on an engine dynamometer instead of a chassis dynamometer. Sales of trucks in the 8,500-10,000 GVWR category have increased to 600,000 units and at about the same growth rate as all light-duty trucks. Additionally, diesel engine sales in the 8,500-10,000 GVWR category have risen to 40 percent of sales over the last five years. Many of these trucks are used in a similar fashion to trucks with a GVWR less than 8,500 pounds. Sales of trucks above 10,000 GVWR are also increasing. In separate regulations, EPA is reevaluating certification requirements and tightening emission standards for heavy-duty gasoline and diesel vehicles. Therefore, changes to the certification requirements for heavy-duty vehicles are beyond the scope of this white paper and EPA does not plan on taking any action regarding these vehicles in the Tier 2 Study.

Certification Fuel Specifications. EPA has historically used a standardized test fuel, called "Indolene," for determining compliance with light-duty exhaust emission standards for gasoline vehicles. This fuel has very low sulfur levels (about 40 ppm) and a relatively simple hydrocarbon composition compared to typical in-use fuels. Preliminary data on vehicles designed to LEV-like emission levels indicate that their emissions may be very sensitive to the

fuel used. Comments are solicited on the need, desirability, and cost of using fuels representative of in-use fuels for compliance purposes, instead of Indolene.

Diesel Engine Exemptions. Currently, diesel engines in LDVs and LDT1 and LDT2 truck classes are allowed to certify to less stringent NOx emission standards than gasoline engines. The CAAA states that these NOx diesel provisions apply only through the 2003 model year. Further, the default Tier 2 emission standards in the CAAA specifically requires EPA to consider the suggested emission levels for both gasoline and diesel engines. Comments are solicited on whether or not diesel engines should be subject to the same NOx standards as gasoline engines in the future. Comments and information are specifically requested on the intent of Congress, the cost of requiring diesel engines to meet the same standards as gasoline engines, and the potential impact of diesel engines on air quality if they are given a NOx waiver as part of Tier 2 standards. A similar issue exists for particulate emissions. Currently, the particulate standards are specifically designed for diesel engines, as gasoline engines have particulate emissions far lower than the standards. Health studies suggest that small particulates, such as those emitted by diesel engines, are a major health hazard. As a readily available technology, the gasoline engine generates much lower particulate levels; this fact raises the issue of whether or not it is appropriate to set less stringent particulate standards based on diesel engines. Comments are solicited on the appropriateness of setting particulate standards specifically for diesel engines, as well as data and information on the potential costs and benefits of setting particulate standards at gasoline emission levels.

Particulate Emissions. As indicated in the previous paragraph, health studies have emphasized the importance of particulate control. In addition to the question of having particulate standards set to diesel emission levels discussed in the last paragraph, there is also a potential issue with gasoline particulate emissions. Even though gasoline particulate emissions are low, the fact that gasoline vehicles are driven over 2 trillion miles per year means that they still may contribute to health problems. Comments are solicited on the need to reassess gasoline particulate emissions.

SFTP Standards. In addition to FTP standards, the technology assessment must consider SFTP standards and the need for particulate standards for the SFTP. Data and information are solicited on how to set SFTP standards associated with Tier 2 FTP standards, as well as data to help assess the need for and the level of particulate standards for the SFTP.

Alternative Fuel Vehicles. Similar to the above discussion regarding diesel engines, there is an open issue as to whether EPA should set fuel-neutral standards (i.e., all vehicles should meet the same standards regardless of the fuel used) or set standards specifically for different types of fuel. Comments are solicited on the appropriateness of setting fuel-neutral standards, as well as data and information on appropriate adjustments for FTP and SFTP standards for alternative-fuel vehicles, should the commenter support different standards for different fuels.

Evaporative Emissions. The CAAA requirements for the Tier 2 Study did not address evaporative emissions. EPA has recently taken several steps to reduce evaporative emissions from light-duty cars and trucks, including enhanced diurnal test procedures, running loss

evaporative requirements, and on-board vapor recovery systems. Comments are solicited on the need to include evaporative emissions in the Tier 2 Study and, if so, what aspects of the evaporative emission requirements should be addressed. Comments are also solicited on the feasibility of establishing a combined exhaust plus evaporative emission NMHC standard, instead of having separate evaporative and exhaust NMHC standards.

Durability/Useful Life. The Tier 2 Study requirement in the CAAA specifically requires EPA to consider, "other standards and useful life periods which are more stringent or less stringent than those set forth in table 3 (but more stringent than those referred to in subsections (g) and (h))." Thus, one of the objectives of the study is to assess the emission benefit and cost tradeoffs between useful life requirements and emission standard levels. Data and information are solicited on the costs and benefits of extending the useful life requirements (from 100,000 to 150,000 miles for LDVs, for example), as well as extending the limitation on in-use testing beyond 75,000 miles (90,000 miles for trucks over 6000 GVWR). Comments are solicited on the feasibility and merit of extending useful life requirements relative to more stringent emission standards.

5. Cost-Effectiveness Assessment

5.1 Introduction

The cost-effectiveness of Tier 2 standards will be compared to alternative means of obtaining reductions. Given the recent work in this area, the Tier 2 Study will build on the efforts of the Subcommittee for Ozone, Particulate Matter and Regional Haze Implementation Programs and OTAG, as well as OAR's Section 812 sector studies.

5.2 Issues

This section frames the potential issues surrounding the key steps and assumptions involved in carrying out the cost-effectiveness assessment. EPA welcomes comments on the issue discussed below, as well as any comments, general or specific, on cost-effectiveness assessment.

Sulfur Impact on Emission Performance. The impact of the sulfur level of in-use fuels on the emission performance of Tier 2 technology needs to be assessed in order to establish the in-use benefits of tighter emission standards. Data and information are solicited on the impact of sulfur on emissions for Tier 2/NLEV technology. EPA also seeks comments on approaches for addressing the potential problem associated with the emissions impact of sulfur.

Table 1. Emission standards and sales estimates for light-duty vehicles and light-duty trucks.

	EPA Tier 1 Standards (50K)			EPA Default Tier 2 Standards(100K)			LEV Standards* (100K/120K)			New vehicle sales 1996†
	NMHC	CO	NOx	NMHC	CO	NOx	NMOG	CO	NOx	
LDV's	0.25	3.4	0.4	0.125	1.7	0.2	0.09	4.2	0.3	60%
LDT1	0.25	3.4	0.4	0.125	1.7	0.2	0.09	4.2	0.3	6%
LDT2	0.32	4.4	0.7	-	-	-	0.13	5.5	0.5	25%
LDT3	0.32	4.4	0.7	-	-	-	0.23	6.4	0.6	2%
LDT4	0.39	5.0	1.1	-	-	-	0.28	7.3	0.9	7%

*LDT3 & LDT4 LEV standards do not apply to NLEV and are for 120K
†An additional 4% of vehicles are trucks between 8,500 & 10,000 GVWR which are subject to heavy-duty standards.

Definitions of Vehicle Classifications:
LDV: All passenger cars
LDT1: Gross Vehicle Weight Rating (GVWR) 0-6000 lb
Loaded Vehicle Weight (LVW) 0-3750 lb
LDT2: GVWR 0-6000 lb
LVW 3751-5750 lb
LDT3: GVWR 6001-8500 lb
Adjusted Loaded Vehicle Weight (ALVW) 0-5750 lb
LDT4: GVWR 6001-8500 lb
ALVW 5751-8500 lb

Gross Vehicle Weight Rating (GVWR) is the value specified by the manufacturer as the maximum design loaded weight of a single vehicle

Loaded Vehicle Weight (LVW) is the vehicle curb weight plus 300 lbs: LVW=VCW+300 lbs

Vehicle Curb Weight (VCW) is the weight of the vehicle with all of its tanks full and components included but no passenger or luggage (load) adjustments (nothing in it).

Adjusted Loaded Vehicle Weight (ALVW) is the average of the vehicles GVWR and the Curb Weight. ALVW=(GVWR+VCW)/2

Table 2. Potential technologies for achieving emission levels below the current Tier 1 standards.

Gasoline Engines
Internal engine modifications
Adaptive transient controls, including drive-by-wire
Electric air injection
Linear exhaust gas and oxygen sensors
Improved "open-loop" control during light-off
Full electronic exhaust gas recirculation, with closed-loop control
Heat-optimized exhaust pipes, including airgap manifolds and downpipes
More active and durable catalyst formulations
Catalyst with duplex loadings (e.g. high inlet Pd loadings for improved light-off)
Increase catalyst volume and precious metal loading
Improved catalyst substrate designs, such as reduced thermal mass, high geometric surface area, and flow-interrupter designs
Electrically heated catalysts
Vacuum insulated catalytic converters
Lean-NOx catalyst or NOx absorber/destruction system for lean-burn engines
Hydrocarbon storage and release systems
Plasma emission control systems

Diesel engines
Improved fuel injection technologies
Direct injection for light-duty vehicles
Internal engine modifications
EGR
Oxidation catalysts
NOx reduction catalyst
NOx absorber/destruction systems
High geometric surface area catalyst substrates
Advanced passive trap systems

Figure 1. Market share for light-duty cars and trucks.